

High-Flow, Noninvasive Ventilation and Awake (Nonintubation) Proning in Patients With Coronavirus Disease 2019 With Respiratory Failure

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e-Appendix 1.**Illustrative case:**

A 53 year old male was admitted to the MICU for COVID-19 with Acute Respiratory Failure (ARF). His symptoms of fever, fatigue, dry cough and finally severe dyspnea started 4 days prior to admission. His throat swab tested positive on reverse transcription-polymerase chain reaction (RT-PCR). CT scan showed multiple ground-glass opacities in both lungs, distributed along the dorsolateral and subpleural areas of the lungs. At admission, vital signs were characterized by normal sensorium, moderate dyspnea (4 on the Borg scale), a respiratory rate of 25 breaths/min, heart rate of 118 beats/min, blood pressure 135/90 and SaO₂ of 91% while breathing supplemental oxygen at 4 L/min through nasal cannula. On a Venturi mask (40% FIO₂), arterial blood gases (ABGs) demonstrated a pH 7.45; PaCO₂ 33 mmHg and PaO₂ of 62 mmHg (PaO₂/FIO₂ of 154). He was placed on helmet noninvasive ventilation (NIV) using an ICU ventilator at an FIO₂ of 40%. Inspiratory and expiratory pressures were gradually increased, until a Pressure Support of 16 cm H₂O and a PEEP of 12 cm H₂O were achieved. The procedure was well tolerated and after one hour, ABGs were pH 7.41; PaCO₂ 34mm; PaO₂ 71 mmHg and SpO₂ 94% (PaO₂/FIO₂ of 177). Since the patient was very compliant and considering the distribution of opacities on the CT scan (bilateral dorsal and subpleural localization), we decided to prone him. He tolerated the procedure well, without need for sedation. After another hour, his ABGs were pH 7.41; PaCO₂ 37; PaO₂ 116 mmHg and SpO₂ 98% (PaO₂/FIO₂ of 290). Four trials of prone position/day were scheduled for a minimum cumulative time of 6 hours. After 4 days (mean NIV daily use of 17 hours), the patient recovered well and required no further ventilatory support. The patient was discharged to a COVID-19 ward on 1 L/m supplemental oxygen with nasal prongs. His ABG showed a pH 7.41; PaCO₂ 39.9; PaO₂ 76.3 mmHg and SpO₂ 96.0%. At day 12, the patient was discharged home without the need for supplemental oxygen.

Discussion of Case

The case illustrates the use of multiple noninvasive modalities to manage severe hypoxemia in a patient with COVID 19 pneumonia. Firm guidelines on how these patients should be managed are lacking, partly because there is paucity of high quality evidence. Also, the disease is highly heterogeneous, with some patients proving to be COVID 19+ after being admitted for reasons like elective surgery and having no respiratory problems and others coming to the emergency department with florid hypoxemic respiratory failure, requiring emergent intubation. Candidates for noninvasive approaches fall between these extremes, with mild to moderate hypoxemia on admission. Most of these patients will be started on standard nasal cannulae as per the algorithm presented in Figure 2, but if they are unable to sustain a SpO₂ of $\geq 92\%$ or are becoming more symptomatic, escalation to more advanced means of delivering oxygen needs to be considered (Step 2 on the algorithm).

When the case reached this point (SpO₂ of 91% on 4L/min), there were a number of options. The patient was placed on a Venturi mask, but many caregivers might have skipped this step, because evidence is clear that a choice like HFNC is better tolerated and a more effective oxygenator than a Venturi mask. When oxygenation was still not adequate, the options were to proceed to HFNC, NIV (or CPAP) or proning alone or with either HFNC or NIV (or CPAP). The choice was to use NIV by helmet with proning that was associated with a substantial improvement in SpO₂. This decision was heavily influenced by the experience and practice at the center in Italy where the patient presented, and where helmet NIV or CPAP has been used for decades. HFNC with proning would have been the preferred choice at many centers in the US, where there is much less experience with the helmet and staff are very comfortable administering HFNC, especially in patients who are to be proned. Although most centers in the US have been reluctant to use NIV due to concerns about aerosol dispersion, there may be some patients who succeed with NIV or CPAP after failing HFNC, and switching would be a consideration prior to intubation in patients who have not deteriorated too rapidly. Either way, these patients must be monitored closely in an ICU or intermediate care setting with intubation done in a timely urgent but not emergent fashion. Finally, it must be reemphasized that whichever of these modalities is used, these are AGP and the recommended PPE and N 95 masks with eye shields should be utilized, preferably in a negative pressure room.